hyperdictionary

AT LEAST: Dictionary Entry and Meaning

WordNet Dictionary

Definition:
1. [adv] not less than; "at **least** two hours studying the manual"; "a tumor at **least** as big as an orange"
2. [adv] if nothing else; "at **least** he survived"; "they felt--at any rate Jim felt--relieved though still wary"; "the influ economists--or at any rate of economics--is far-reaching"; (`leastwise' is informal; `leastways' is colloquial)

Synonyms: at any rate, at the **least**, leastways, leastwise

Antonyms: at most, at the most

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APA Active Pak Automation

Protection of Pharmaceutical And Diagnostic Products Through Desiccant Technology

By Rodney L. Dobson, Multisorb Technologies Inc.

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Moisture trapped within a product package or leaking into it during storage and shipping can cause many harmful effects. The stability of many **pharmaceutical** formulations and diagnostic reagents, as well as the maintenance of their physical product integrity, is often closely tied to the moisture conditions of the package environment. In unsterilized or poorly sterilized situations, moisture can promote the growth of mold, mildew and fungus. Products using some polymers are prone to swelling in high humidity conditions as intermolecular bonding between polymer chains can be weakened by the presence of water. In some cases water can become an integral part of the bulk crystal structure of a product through the formation of hydrates. If a solid is very water soluble, such as a sugar coating, and the right conditions exist, dissolution into the sorbed layer can trigger irreversible water uptake and subsequent deliquescence. The solution -- proper selection of the right desiccant can be inexpensive insurance for protecting your packaged product. Product quality can be improved, resulting in reduced or eliminated customer rejections.

When dealing with moisture problems in packaging, a wide array of variables can make it difficult or confusing to develop solutions. These variables can be classified into two main groups: 1) those pertaining to the product, its package, and the environment; 2) the physical and chemical properties of commercially available desiccants.

Environment

The conditions under which the product is packaged, stored and shipped must all be thoroughly considered when designing for moisture control. Temperature and relative humidity are two of the most influential environmental factors. At the time of packaging, the product becomes sealed at the conditions of the packaging room. The air trapped in the package is the first source of moisture which we will consider.

The moisture content of the air can be defined by its relative humidity. Relative humidity is the ratio of the quantity of water vapor actually present in the air to the quantity which would saturate the air at the existing temperature. Table 21 shows the saturated vapor pressure of water in air at various temperatures. Relative humidity (RH) is then equal to the partial pressure of water vapor actually present in the air (P) divided by the saturated vapor pressure (Psat) expressed as a percentage:

$P/PSat = RH$

For example, when the weather report gives the relative humidity at 60%, at a temperature of 90°F, we know that P/PSat = 0.60. In Table 1, we find that Psat at 90° F is 0.698 PSIA. Thus, we can calculate the actual vapor pressure of water:

$P = RH \times Psat = 0.60 \times 0.698 \text{ PSIA} = 0.419 \text{ PSIA}$

Why would calculating the actual vapor pressure of water be important? If you seal the container on that particular day, the water content of the container is then fixed.

Table 1 Multisorb Technologies, Inc.

Water Vapor Data

Dew Point. Deg.F	Vapor Pres PSIG	Water Content Grams/FT^3	Dew Point. Deg.F	Vapor Pres PSIG	Water Content Grams/FT^3

-50	0.0009776	0.0018	-10	0.01082	0.0183
-49	0.001004	0.0019	-9	0.01143	0.0193
-48	0.001115	0.0021	-8	0.01207	0.0203
-47	0.00119	0.0022	-7	0.01274	0.0214
-46	0.00127	0.0023	-6	0.01344	0.0226
-45	0.001354	0.0025	-5	0.01419	0.0238
-44	0.001444	0.0026	-4	0.01496	0.025
-43	0.001539	0.0028	-3	0.01578	0.0263
-42	0.001641	0.0030	-2	0.01664	0.0277
-41	0.001748	0.0032	-1	0.01754	0.0291
-40	0.001861	0.0034	0	0.01849	0.0306
-39	0.001982	0.0036	1	0.01948	0.0322
-38	0.00211	0.0038	2	0.02052	0.0338
-37	0.00245	0.0044	3	0.02116	0.0348
-36	0.002388	0.0043	4	0.02276	0.0374
-35	0.00254	0.0046	5	0.02396	0.0393
-34	0.0027	0.0048	6	0.02521	0.0412
-33	0.00287	0.0051	7	0.02653	0.0433
-32	0.003049	0.0054	8	0.02791	0.0454
-31	0.003239	0.0058	9	0.02936	0.0477
-30	0.00344	0.0061	10	0.03087	0.0500
-29	0.003652	0.0065	11	0.03246	0.0525
-28	0.003876	0.0068	12	0.03412	0.0551
-27	0.004113	0.0072	13	0.03585	0.0577
-26	0.004363	0.0077	14	0.03767	0.0605
-25	0.004627	0.0081	15	0.03957	0.0635
-24	0.004905	0.0086	16	0.04156	0.0665
-23	0.005199	0.0091	17	0.04363	0.0697
-22	0.005509	0.0096	18	0.04581	0.073
-21	0.005836	0.0101	19	0.04808	0.0765
-20	0.006181	0.0107	20	0.05045	0.0801
-19	0.006545	0.0113	21	0.05293	0.0838
-18	0.006928	0.0119	22	0.05552	0.0877
-17	0.007332	0.0126	23	0.05823	0.0918
-16	0.007757	0.0133	24	0.06015	0.0961
-15	0.008204	0.0140	25	0.064	0.1005
-14	0.008676	0.0148	26	0.06708	0.1051
-13	0.009172	0.0156	27	0.0703	0.1100

-12	0.009694	0.0165	28	0.07365	0.1150
-11	0.01024	0.0174	29	0.07715	0.1202
10	.	.	.	.	.
30	0.0808	0.1256	70	0.36304	0.5218
31	0.08461	0.1313	71	0.037561	0.5389
32	0.08858	0.1372	72	0.38856	0.5564
33	0.09223	0.1425	73	0.4019	0.5744
34	0.096	0.148	74	0.41564	0.5929
35	0.0991	0.1538	75	0.42979	0.612
36	0.10396	0.1597	76	0.44435	0.6315
37	0.10815	0.1658	77	0.45935	0.6516
38	0.11249	0.1721	78	0.47478	0.6723
39	0.11699	0.1786	79	0.49066	0.6935
40	0.12164	0.1853	80	0.50701	0.7153
41	0.12646	0.1923	81	0.52382	0.7376
42	0.13145	0.1995	83	0.54112	0.7606
43	0.1366	0.2069	83	0.55892	0.7841
44	0.14194	0.2145	84	0.57722	0.8083
45	0.14746	0.2224	85	0.59604	0.8331
46	0.14517	0.2306	86	0.6154	0.8586
47	0.15907	0.239	87	0.6353	0.8848
48	0.16517	0.2477	88	0.65575	0.9116
49	0.08461	0.2566	89	0.67678	0.9391
50	0.17799	0.2659	90	0.69838	0.9673
51	0.18473	0.2754	91	0.72059	0.9963
52	0.19169	0.2852	92	0.7434	1
53	0.198888	0.2953	93	0.76684	1.0564
54	0.2063	0.3058	94	0.79091	1.0876
55	0.21397	0.3165	95	0.82564	1.1196
56	0.22188	0.3276	96	0.84103	1.1523
57	0.23006	0.339	97	0.86711	1.1859
58	0.23849	0.3507	98	0.89388	1.2204
59	0.2472	0.3628	99	0.92137	1.2556
60	0.25618	0.3753	100	0.94959	1.2918
61	0.26545	0.3881	101	0.97854	1.3288
62	0.27502	0.4014	102	1.0083	1.3668
63	0.28488	0.415	103	1.0388	1.4056
64	0.29505	0.4289	104	1.07	1.4456

65	0.30554	0.4434	105	1.1021	1.486
66	0.31636	0.4582	106	1.1351	1.5278
67	0.3275	0.4734	107	1.1688	1.5704
68	0.339	0.4891	108	1.2035	1.6141
69	0.35084	0.5052	109	1.239	1.6588
110	1.2754	1.7046	131	2.2838	2.9438
111	1.3128	1.7515	132	2.3452	3.0179
112	1.351	1.7993	133	2.4081	3.0936
113	1.3902	1.8483	134	2.4725	3.171
114	1.4305	1.8985	135	2.5382	3.2487
115	1.4717	1.9498	136	2.6055	3.3303
116	1.5139	2.0022	137	2.6743	3.4125
117	1.5571	2.0558	138	2.7446	3.4964
118	1.6014	2.116	139	2.8165	2.582
119	1.6468	2.1667	140	2.89	3.6693
120	1.6933	2.2241	141	2.9651	3.7584
121	1.7409	2.2826	142	3.00419	3.8494
122	1.7897	2.3426	143	3.1204	3.9421
123	1.8396	2.4038	144	3.2006	4.0368
124	1.8907	2.4663	145	3.2825	4.1332
125	1.943	2.5302	146	3.3662	4.2316
126	1.9966	2.5956	147	3.4517	4.3320
127	2.0514	2.6623	148	3.539	4.4342
128	2.1075	2.7304	149	3.6282	4.5385
129	2.1649	2.8000	150	3.7194	4.645
130	2.2237	2.8712	151	3.8124	4.7533

Looking at Table 1, as the temperature drops, the saturation water vapor pressure decreases. The temperature at which the actual vapor pressure equals the saturated vapor pressure is called the dewpoint. Any additional drop in temperature will result in dew formations. The amount of water in the air has then exceeded the saturation point and the additional water is "squeezed out" as condensation.

In the case above, the dewpoint is between 74° and 75°F (found by matching the water vapor pressure calculated above, 0.419 PSIA, to the corresponding dewpoint temperature). The most moisture vapor the air can hold without condensation at this dewpoint is about 0.6 grams per cubic foot of air (Table 1). If the temperature is reduced to 50° F, the air can only hold

about 0.27 grams per cubic foot. The result, with no desiccant, would be that 0.33 grams per cubic foot of air (0.60-0.27) would be squeezed out as condensation.

Condensation occurring within your packaged product is usually the worst case scenario. This case provides the most dramatic visual observations of the effects of moisture damage. In most cases the packaging expert is concerned with maintaining the moisture level below some threshold level, usually substantially lower than where condensation occurs, where the stability of the product or other components becomes affected. An effective desiccant will adsorb water vapor from the air in a package, lowering the relative humidity to the point where condensation will no longer occur or the threshold relative humidity is never exceeded under the conditions which the package will be exposed.

How much water should be removed by the desiccant from the package? The answer depends upon many variables. For instance, under a given set of humidity and temperature conditions how much water will be taken up by the product? How fast is the water taken up? What is the mechanism by which the moisture harms the product? Can these effects be reversed by drying? What are the effects of over-drying the product? What are the properties of other packaging components? Can they interact, in the presence of moisture, to alter the performance of the product? These questions are usually answered through empirical study.

In most cases, designing the package and the desiccant to maintain an internal relative humidity of 10-12% at normal room temperature conditions of about 70°F, will provide adequate protection. It is strongly suggested that the desiccant supplier be contacted to discuss the elements of the package and the level of protection required.

Packaging and Product Water Sources

During transport and storage, moisture can accumulate in the package by: 1) being emitted from the dunnage (wood, felt, foam, paper, etc.) used to support or retain the product: 2) by being emitted from the product itself: 3) by entering slowly through the protective barrier of the package.

In a closed package, the desiccant will work to adsorb moisture from all sources. Some plastics (such as nylon), foams, paper, wood, felt, cotton and polyester can all contain moisture. Wood, cotton and paper can hold 14% or more, and some foams up to 10%. The moisture contained in these materials can be emitted

into the air as the desiccant dries the air space around it or as the temperature increases. The quantity of desiccant used must account for the water which can be emitted from these sources. How much of the water contained in these sources will ultimately be adsorbed by the desiccant depends upon: how strongly the moisture is bound by that source (chemisorption or physical adsorption); the type of desiccant and quantity used; how much water has already been adsorbed by the desiccant; and the temperature.

For instance, suppose the product is retained by a cotton coil. The cotton typically contains 5-10% moisture by weight. Much of the moisture contained in the cotton is relatively loosely bound. As the desiccant in the container adsorbs moisture from the airspace, moisture is then given up by the cotton to the airspace in an attempt to reach a new equilibrium. This process will continue until an overall equilibrium is reached between the desiccant, cotton coil and the airspace. The desiccant adsorbs moisture much more strongly than the cotton (comparing their heats of adsorption/desorption) and will continue to dry out the cotton until it is either saturated or no more moisture is available.

A well-designed package is usually protected by a barrier film, such as polyethylene, preferably with a low moisture vapor transmission rate (MVTR). The MVTR of the barrier depends upon the type and thickness of the materials used and the external environmental conditions. Table 2 provides the MVTR for a number of barrier materials. Knowing the MVTR (in grams of water per square foot per day), the total surface area of the barrier (package surface area) and the length of time in storage, you can calculate the amount of moisture penetrating the package over time. This moisture must also be removed by the desiccant to protect against possible condensation within the package or damage to the product due to the high humidity.

Table 2

	MV TR*	
Material	**gm/m^2-day**	**gm/ft^2-day**
Aluminum Foil Wrapping 0.025 mm	0.5	0.05
Aluminum Foil Wrapping 0.009mm	1.0	0.09
Cellulose Films ('Cellophane') 400's MXXT Grade (Polyvinylidene Chloride Coated) Polyvinylidene/Polyvinyl Chloride Films ('Saran') 0.005 cm (0.002 in)	1.5	0.14

Polyvinylidene/Polyvinyl Chloride Films ('Saran') 0.0013 cm (0.0005 in)	3.0	0.28
Polyethylene Films ('Polythene') 0.0125cm (0.005in) Waxed Paper (45.5 kg (100 lb) per DC Ream)	4.0	0.37
Cellulose Films ('Cellophane') 300's MSAT Grade (Cellulose Nitrate Coated)	7.5	0.70
Glassine Lacquered (16 kg (35 lb) per DC Ream)	9.0	0.84
Polyethylene Film ('Polythene') 0.005 cm (0.002) in)	10.0	0.93
Polyethylene Film ('Polythene') 0.0025 cm (0.001 in)	20.0	1.86
Polyethylene Coated Kraft (9kg (20 lb) per DC Ream)	30.0	2.79

*Determined at 100°F and 90% RH

Moisture can leak into the product container even with a highly effective moisture barrier, such as glass. In a bottle type package, the moisture leaking through the bottle/cap joint is often the single largest source of moisture. The MVTR of a bottle/cap arrangement is often evaluated by using a known weight of desiccant, having a known moisture content, which is placed into a bottle. The cap is then affixed under the same conditions for all samples. The bottle is then placed in a controlled atmosphere (typically 20° C and 75% RH) and the amount of moisture pick-up by the desiccant measured as a function of time. The MVTR is then specific to that bottle/cap combination. The MVTR will change as the size of the bottle changes. Larger bottles have more surface area exposed for MVTR. Finish sizes can vary between bottles of the same or different volumes (larger finishes provide more potential for moisture leakage), and the materials of construction can vary (wax seals, foil seals, phenolic caps, metal caps, etc.)

Desiccant Selection
It is important to understand how the desiccant does its job of protecting the product. Most porous **adsorbents**, such as silica gel, activated clay or molecular sieves rely upon physical adsorption rather than chemisorption to accomplish their function. Physical adsorption involves relatively weak intermolecular forces (van der Waals forces and electrostatic

interactions) between the moisture and surface of the desiccant. Chemisorbents, such as calcium oxide, involve an actual chemical bond. Physical adsorption of moisture is typically exothermic. The strength of the adsorptive bonds can thus be measured by the heat of adsorption. The higher the heat of adsorption for moisture on the desiccant, the stronger the bonding and the less easily that moisture can be subsequently removed.

In a porous desiccant, water is removed from the airspace by: 1) multilayer adsorption, which is the attraction of thin layers of water molecules to the surface of the desiccant. Because the desiccant is very porous, the surface area is high and significant amounts of water can be attracted and adsorbed; 2) by capillary condensation in which the smaller pores become filled with water. Capillary condensation occurs because the saturation water vapor pressure in a small pore is reduced by the effect of surface tension.

Capillary condensation cannot only occur in the adsorbent but in the small pores or crevices of your product as well. The harmful results of moisture condensation can potentially occur in some products at humidity levels below that which might be predicted by looking at the bulk airspace of the package.

Figure 1: Adsorption Rate (H_2O) of Various Adsorbents

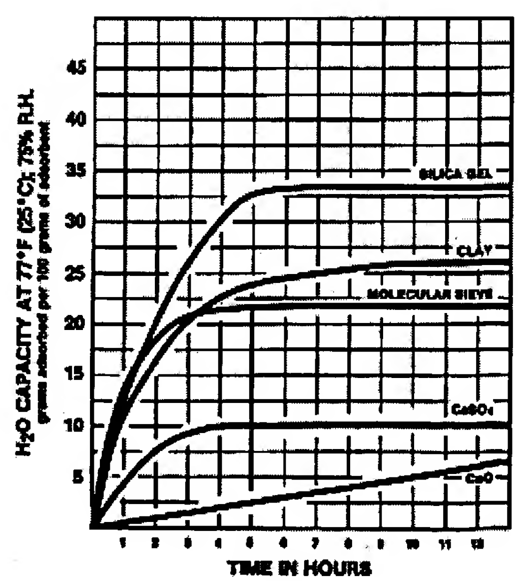


Figure 2: Equilibrium Capacity (H_2O) of Various Adsorbents

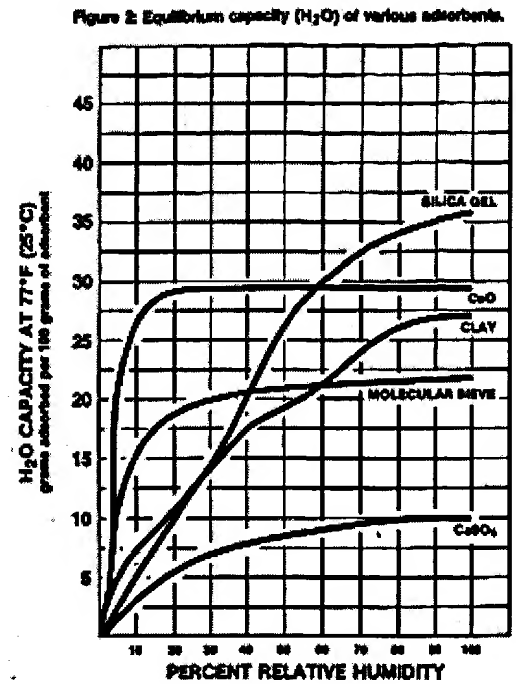
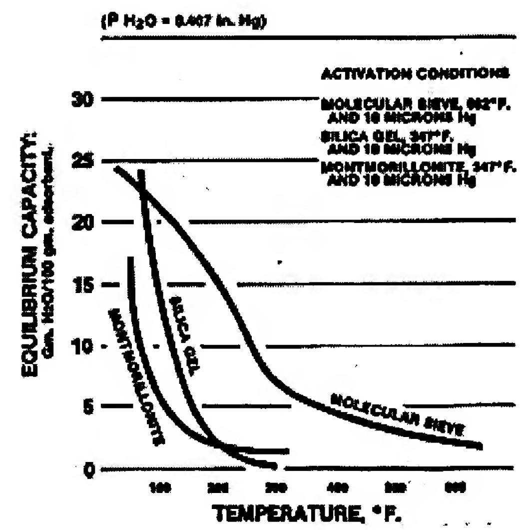


Figure 3: Equilibrium H_2O Capacity



To this point, we have determined the amount of moisture which must be removed from the air in the package, the dunnage, the product itself and from moisture penetrating through the barrier. By comparing the capabilities of each type of desiccant and the needs of the package for protection, proper selection of the desiccant can be made.

Figures 1, 2 and 3 illustrate comparative desiccant properties. Figure 1 shows adsorption rates - how quickly the desiccant adsorbs water vapor inside the package. Figure 2 compares equilibrium adsorption capacity - how much water vapor can be adsorbed by the desiccant at various relative humidities. It is

important to note that the equilibrium moisture capacity of the desiccant in a package is defined by the relative humidity you chose as a threshold limit, not by stating humidity conditions of the packaging room. Figure 3 compares adsorptive capacities of desiccants at various temperatures.

The desiccant properties in Figure 3 become particularly important during shipping and handling of the package. For example, a product is packaged in a typical room at 77°F and 40% relative humidity. Clay has an equilibrium capacity of about 17.5 weight percent (17.5 grams of water adsorbed per 100 grams of clay - Figure 2 and 3) at these conditions. Let's assume the quantity of desiccant used is just sufficient to adsorb the moisture from the airspace, dunnage, etc. and is now saturated. The product is shipped in a poorly ventilated truck on a sunny day where the package temperature increases to 100°F. Under these conditions, the clay's equilibrium adsorption capacity is now only wt.% or less (Figure 3). The excess water, which the clay can no longer hold, is desorbed into the airspace of the package. The package is then unloaded onto an unheated receiving dock, where the temperature is now only 50°F. As the clay cools, it readsorbs the water. Being a good insulator, however, it does not usually cool as quickly as the package itself. The result is the potential for condensation within the package -- even though none occurred prior to shipment and no additional water was introduced into the package during shipment. Proper selection of the type and quantity of desiccant used can avoid this type of problem. For instance, molecular sieve's capacity for water adsorption is very good, and changes very little under these conditions.

Table 3 summarizes the general capabilities of molecular sieves, silica gel, montmorillonite clay, calcium oxide and calcium sulfate. It is up to the packaging engineer to decide which properties of the desiccant are important to his packaging situation and to select the appropriate desiccant.

Montmorillonite Clay

Montmorillonite Clay is a naturally occurring porous adsorbent. The mined clay is activated for use as a desiccant through careful drying. This clay will successfully regenerate for repeated use at very low temperatures without substantial deterioration or swelling. However, this property causes clay to desorb moisture readily back into the container as temperatures rise. Clay is inexpensive and effective within normal temperature and relative humidity ranges (Table 3). Some variation in performance can be seen due to its source as a naturally occurring material.

Care should be taken to be sure that any low level impurities in the clay are not incompatible with the packaged product.

Table 3:

Properties of Adsorbents

Property	Molecular Sieve	Silica Gel	Montmor-illonite Clay	CaO	$CaSO_4$
Adsorptive Capacity At low H_20 Concentrations	Excellent	Poor	Fair	Excellent	Good
Rate of Adsorption	Excellent	Good	Good	Poor	Good
Capacity For Water @77° F, 40% RH	High	High	Medium	High	Low
Separation by Molecular Sizes	Yes	No	No	No	No
Adsorptive Capacity Elevated Temperatures	Excellent	Poor	Poor	Good	Good

Silica Gel
The most commonly used desiccant in the **pharmaceutical** industry is silica gel. Silica gel is a partially dehydrated form of polymeric colloidal silicic acid. Silica gel has an amorphous microporous structure with a distribution of pore opening sizes of roughly 3-60 angstroms. These inter-connected pores form a vast surface area that will attract and hold water by adsorption and capillary condensation, allowing silica gel to adsorb up to 40% of its weight in water. Silica gel is extremely efficient at temperatures below 77°F (25°C) (see Figures 1 and 2), but will lose some of its adsorbing capacity as temperatures begin to rise, much like clay (Figure 3). Much of silica gel's popularity is due to its non-corrosive, non-toxic nature and its having received U.S. government approval for use in food and drug packaging.

Silica gel can also be impregnated with a cobalt chloride indicator which changes from blue to pink when about 6% water by weight has been adsorbed. An indicating desiccant is particularly useful as a quick visual aid in determining whether the desiccant has been exposed to significant quantities of moisture.

As with clay, silica gel, with its wide range of pore sizes, has the capability of adsorbing compounds other than water. The relative order of adsorbability is: water, ammonia, alcohols, aromatics, diolefins, olefins and paraffins. When the potential for multicomponent adsorption is present, expect the more strongly adsorbed compounds, such as water, to displace the more weakly held ones.

Molecular Sieve (Synthetic Zeolite)
Molecular sieves are porous crystalline aluminosilicates. The distinctive feature of the molecular sieve structure, as compared to the other desiccants, is the uniformity of the pore size openings in the crystal lattice structure. There is no pore size distribution with molecular sieves. This feature allows the selection of a molecular sieve product which can adsorb water, yet exclude most other molecules, such as volatile organics, which might be present in the package. For example, Type 3A molecular sieve's structure, with a 3 angstrom pore opening, allows moisture adsorption, but excludes most hydrocarbons. Type 4A molecular sieve has a slightly higher moisture capacity, but adsorbs molecules as large as butane. Type 13X molecular sieve has a different crystal structure from the types 3A and 4A, and has a pore opening of about 10 angstroms. This allows for the adsorption of a wide range of organic molecules as well as moisture. The selective adsorption characteristics of molecular sieves can be useful when it is necessary to dry a package without removing other desirable compounds from the system.

Molecular sieves adsorb moisture more strongly than either silica gel or clay. This can be seen by the high initial slope of the adsorption isotherm for molecular sieve as compared to the other desiccants (Figure 2). This can also be seen in comparing their heats of adsorption for water. The heat of adsorption is the sum of the latent heat of vaporization of water and the heat of wetting. The heat of wetting will vary as a function of the saturation level of the desiccant. For purposes of comparison, the heat of adsorption for water on molecular sieve is about 1800 BTU/lb. of water adsorbed, as compared to 1300 BTU/lb. of water adsorbed on silica gel. Clay is roughly similar to silica gel in this respect. What does this mean? Where a very low relative humidity is required, molecular sieves are often the most economic desiccant because of their high adsorption capacity at low relative humidity. Also, molecular sieves will not desorb moisture into the package as readily as silica gel or clay as temperatures rise (Figure 3). This is particularly important to packaged products which can potentially see a wide variety of environmental conditions.

Being man-made rather than naturally occurring, molecular sieve is slightly higher in cost per unit, but due to its extremely large range of adsorptive capabilities, it might often be the best value. Lack of government approval for the use of molecular sieves in food and drug packaging has limited its more widespread use. Independent testing suggest that molecular sieves meet government requirements. Presumably, however, the industry has been unwilling to fund the expensive testing required for government approval.

Calcium Oxide (CaO)
Calcium oxide is calcinated or recalcinated lime having a moisture adsorptive capacity of not less than 28.5% by weight. The distinguishing features of calcium oxide (also known as Quick Lime) are: it will adsorb a much greater amount of water at low relative humidity than other materials (Figure 2); it is effective in retaining moisture at high temperatures; and it is relatively inexpensive as compared to many other desiccants.

Calcium oxide removes water from a package very slowly, often taking days to reach its maximum capacity. As calcium oxide adsorbs moisture, it swells. Proper desiccant packaging is required for effective use. For these reasons, its use has been limited to primarily the packaging of dehydrated foods.

Calcium Sulfate (CaSO4)
Calcium sulfate (better known commercially as Drierite™) is created by the controlled dehydration of gypsum. It is a general purpose desiccant geared mainly toward laboratory use. It is chemically stable, non-disintegrating, non-toxic, non-corrosive and does not release its adsorbed water easily when exposed to higher ambient temperatures. The low cost of calcium sulfate must be weighed against its equally low adsorptive capacity; it adsorbs only up to 10% of its weight in water vapor (Figure 2).

Other Adsorbents
Other **adsorbents** are available for specialized functions. For example, activated alumina is another porous desiccant which performs very similarly to silica gel, providing somewhat lower moisture capacity at low temperatures, but slightly improved capacity at higher temperatures. Activated carbon has long been used as an adsorbent for odor and toxic gases. Other metal salts and phosphorous compounds have also been used in special situations.

Cover Stock (Desiccant Package Material)
An important factor in the efficiency of the selected desiccant is the container material (cover stock) for the desiccant. The

cover stock must allow the desiccant to do its job without harming the product. This means maintaining an acceptable adsorption rate while conforming to the product's dusting, chemical compatibility and size requirements. The selected desiccant's adsorption rate is greatly affected by the water vapor transmission rate of its cover stock. This is the measure of the gain or loss of water vapor through the package of the bagged desiccant.

By their nature, many **pharmaceutical** and diagnostic products require a non-dusting desiccant bag container. Most paper and other non-woven cover stocks allow dusting. While dealing with dusting requirements, the packaging engineer encounters another problem: in preventing the release of dust into the container, the water vapor transmission rate may also be adversely affected.

The search for an appropriate cover stock led Multisorb Technologies, Inc. to the development of desiccant packages using a spunbonded, high density polyethylene material known commercially as Tyvek®. Created by DuPont, Tyvek resembles a waxy paper with good whiteness, exceptional strength, maintains its size and shape with changes in humidity and can be used in food and drug packaging. It will not allow dust to be released into the container, is resistant to staining and mildew growth and will not reduce the adsorption rate of the desiccant it holds.

When Tyvek is sealed with a thermoplastic lamination (a coating requiring heat and pressure to seal the package closed), it may lose part of its permeability. These coatings are also solvent or water based and can be vaporized into the airspace of the package. It is possible that direct contact with this type of desiccant package or the out-gassed products could be harmful to the product being protected. Thus, Multisorb Technologies developed and patented a process that will heat seal the bag by joining Tyvek directly to itself, the MINIPAX™ product, with no adverse effect on the adsorption rate. As no heat seal coating is used, many concerns can be eliminated. The unique window in the back of the packet also allows you to use an indicating desiccant to tell when its moisture adsorption capacity has been reached.

Your Choice

A sealed package without desiccant runs the risk of moisture damage. Even a good moisture barrier and stringent packaging conditions do not eliminate this problem. Once the air within the container reaches its dewpoint or some critical relative

humidity, such as in a cold truck, warehouse or in overseas shipment, moisture damage will occur.

Carefully consider the sources and quantity of moisture, the level of moisture protection needed and then select the desiccant and desiccant package which best fits your needs. It is inexpensive insurance to protect valuable product.

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